

FINAL REPORT

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Pristine Igneous Rocks and the Early Differentiation of Planetary Materials

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Our studies are highly interdisciplinary, but are focused on the processes and products of early planetary and asteroidal differentiation, especially the genesis of the ancient lunar crust. Most of the accessible lunar crust consists of materials hybridized by impact-mixing. Rare pristine (unmixed) samples reflect the original genetic diversity of the early crust. We studied the relative importance of internally generated melt (including the putative magma ocean) versus large impact melts in early lunar magmatism, through both sample analysis and physical modeling. Other topics under investigation included: lunar and SNC (martian?) meteorites; igneous meteorites in general; impact breccias, especially metal-rich Apollo samples and polymict eucrites; effects of regolith/megaregolith insulation on thermal evolution and geochronology; and planetary bulk compositions and origins.

We investigated the theoretical petrology of impact melts, especially those formed in large masses, such as the unejected parts of the melts of the largest lunar and terrestrial impact basins. We developed constraints on several key effects that variations in melting/displacement ratio (a strong function of both crater size and planetary g) have on impact melt petrology. Modeling results indicate that the impact melt-derived rock in the sampled, megaregolith part of the Moon is probably material that was ejected from deeper average levels than the non-impact-melted material (fragmental breccias and unbrecciated pristine rocks). In the largest lunar impacts, most of the impact melt is of mantle origin and avoids ejection from the crater, while most of the crust, and virtually all of the impact-melted crust, in the area of the crater is ejected. We investigated numerous extraordinary meteorites and Apollo rocks, emphasizing pristine rocks, siderophile and volatile trace elements, and the identification of primary partial melts, as opposed to partial cumulates. Apollo 15 sample 15434,28 is an extraordinarily large glass spherule, nearly if not entirely free of meteoritic contamination, and provides insight into the diversity of mare basalts in the Hadley-Apennine region. Apollo 14 sample 14434 is in many respects a new rock type, intermediate between nonmare gabbroanites and mare basalts. We helped to both plan and implement a consortium to study the Yamato-793605 SNC/martian meteorite. Yamato-793605 is remarkably similar

to two other martian meteorites, ALH77005 and LEW88516, and we infer a strong possibility that this trio left Mars as a single mass, but was broken apart by asteroid-asteroid collision(s) en route to Earth. We used mass balance modeling for MgO and FeO to constrain the origins of HED meteorites; results imply the eucrites probably formed mainly as extruded residua from a diogenite-parental magma ocean. For two lunar meteorites found on opposite sides of Antarctica, our detailed study (e.g., comparison of their mare pyroclastic spherules) virtually proves that both came, by separate paths, from the same launch crater on the Moon.

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